canusa Newsletter

Canada
United States
Spruce Budworms
Program

NUMBER 9, MARCH 1980

## Spruce Budworm Pheromones

In the 1950's and 1960's workers in New Brunswick showed that virgin female spruce budworm moths (*C. fumiferana*) could be used as effective lures to attract males, and work was begun on the chemical identification of the sex pheromone of this species. This project was moved to Sault Ste. Marie, Ontario, in the late 1960's, and developed into a cooperative program between workers at Cornell University and the Canadian Forestry Service (CFS). In 1971 it culminated in the identification of the major pheromone component as E-11-tetradecenal.

At the same time, workers in the Forest Service, USDA, became interested in the use of the sex pheromone of the western spruce budworm (*C. occidentalis*), and it was found that the same chemical was a powerful attractant for males of that species too. This started a cooperative program between the west and the east which is continuing.

Anomalous trap catches in the east, using batches of synthetic attractant obtained in 1972 from different chemical companies, prompted a reinvestigation of the pheromone of the spruce budworm. It was subsequently found that the aldehyde emitted by female moths was, in fact, a blend of the two geometrical isomers in the ratio of approximately 96E:4Z. More recently other workers have put the figures nearer 95:5 and extensive field trapping over a large part of the range of the spruce budworm showed maximum catches of males in the range 95 to 97 percent E. Western spruce budworm females have been found to emit a blend closer to 90E:10Z, but no difference in catches has been found over the range 85 to 97 percent E. Several investigators have looked for evidence of other compounds released by the females which may play a role in short or long range communication, but none has been found. Negative evidence is never very conclusive, and the door must remain open to the possibility that other chemicals are involved.

Sex attractants offer the pest manager two potential tools: a) a sensitive inexpensive survey tool, b) a method of regulating population growth by disrupting mating behavior. The philosophy behind the practical use of the synthetic attractant is the same east and west, except that in the east, the emphasis on the use of traps is to detect outbreaks, while in the west it is on the prediction of damage.

## Trapping

Early in our research program we concluded that population regulation by trapping males was impractical; the cost and problems of deploying sufficient traps would be prohibitive. Work was concentrated, therefore, on the use of traps for two purposes: to serve as early warning devices for alerting the forest manager to population surges during the endemic phase which might be the beginning of an outbreak, and for predicting damage (percent defoliation) in the following year.

Sampling low density populations by conventional means (larvae, eggs) is notoriously time-consuming. Traps are cheap and efficient. Efficiency is measured not by the numbers caught, but by how accurately changes in catch from year to year reflect changes in population density or subsequent damage. Accurate estimates of absolute population density are unnecessary, which is fortunate, since the relationship will certainly vary with stand composition. Because of the large areas involved, traps cannot be visited regularly. Ideally the same trap should be left out from the beginning to the end of the flight periods, which allowing for annual variations, means a period of 5 to 6 weeks. During this time the traps must retain their shape and stickiness and must not become too contaminated by extraneous debris and nontarget insects. Furthermore, they should be inexpensive and standardized from year to year. Bearing this in mind, the Pherocon 1CP has been chosen as the most suitable trap in the east, while in the west, less expensive, homemade "milk carton" traps are being used. CANUSA is currently funding a project at Michigan State University for the development of a nonsticky, high capacity trap which may avoid the problems of saturation experienced with sticky traps.

The second component of the trapping system is the lure. Here, the criteria are a known, uniform release rate over the trapping period, and standardization from year to year. During the development work in both east and west we have used a PVC formulation developed by Oregon State University in cooperation with the Forest Service, USDA. The properties of this formulation have been thoroughly investigated and it is ideal for the purpose. However, other commercial formulations could work just as well. Unfortunately, techniques for accurately measuring release rates still have their problems. A promising new technique using bioluminescence is currently under investigation in a joint CFS/McGill University project funded by CANUSA. Until release rates can be accurately measured, changes from one formulation to another in an ongoing trapping program should be avoided, as it will prevent the comparisons of results from year to year.

Practical use of the traps awaits their calibration against changes in population density or damage levels. Early work is encouraging; correlations do exist, and it should be possible to establish thresholds of value to the forest managers. The need now is to extend this work to more areas and more stand types.

## Disruption

The exact nature of disruption — the permeation of the atmosphere with chemicals which results in fewer virgin females mating — has not been resolved. Small scale field experiments have shown that permeation of the atmosphere with synthetic attractant reduces the numbers of male spruce budworm moths (*C. fumiferana*) caught in traps baited with virgin females, and suggest that disruption of orientation is greatest with blends closest to the natural attractant.

In large scale trials against the spruce budworm (*C. fumiferana*) we have used a blend of the synthetic attractant close to the 95:5 ratio of E:Z. The first trial was carried out in Ontario in 1975 when the synthetic attractant, formulated in NCR microcapsules, was applied to an isolated 12 ha white spruce stand at the rate of 20 capsules/$cm^2$ (7.4 g of the attractant per hectare). The objective was limited to demonstrating that the presence of the synthetic attractant would affect orientation, and in this it was successful for catches in traps baited with virgin females were reduced by 96 percent when compared to a check area. This paved the way for more ambitious trials in 1977, designed to determine if density of the subsequent generation would be reduced.

In order to allow a more accurate monitoring of deposit and release rates, the attractant for these trials was formulated in hollow plastic fibers developed by Conrel, the logic being that the fibers would be easy to locate, the release rates could be easily determined by successive measurements of the minisci in the fibers. Unfortunately this did not work out; the polybutene sticker evidently interfered with the evaporation rate of the attractant and release rates could not be determined.

The material was applied to a 250 ha white spruce plantation near Sault Ste. Marie, Ontario, infested by a moderate population density of spruce budworms, to give a theoretical release rate of 7 mg per ha per hr at 21°C, and to two 10 ha plots in an area of endemic populations in northwestern Ontario to give release rates of 10 and 1 mg per ha per hr, respectively. In all 3 treated plots, catches in traps baited with virgin females were reduced by 99 percent compared to the check plots. Application of the material was late in the higher density area, however, and some eggs were laid prior to application; but, following application, there was a significant reduction in oviposition. No egg sampling was attempted in the low density populations, but a survey of overwintering larvae showed no differences due to the treatments. This could be attributed to a number of possible reasons; difficulties in sampling overwintering larvae, plots too small, as well as ineffective treatment.

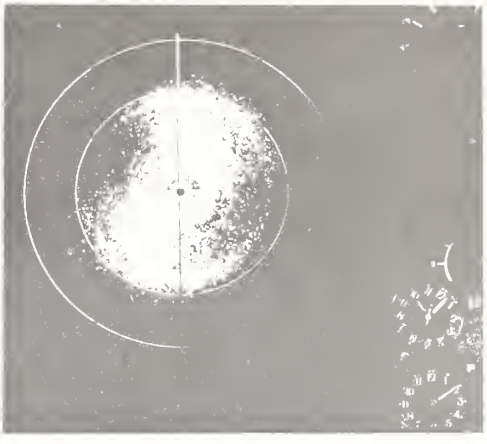
In 1978, trials with the same objective were carried out in the Maritimes, but with the addition of determining the effects of four different application rates. The operation was a joint project funded by New Brunswick, Nova Scotia and the Canadian Forestry Service (CFS). Plots were 100 ha in size and each treatment was replicated with one series in New Brunswick and one in Nova Scotia giving a total of eight treated plots. Conrel fibers were used again, only this time the fibers were crimped in the middle. Unfortunately this formulation did not perform as hoped, the attractant evidently evaporated in about 10 days, and so the bulk was gone before the main moth flight. Some effects on trap catches and mating success of tethered and caged females were recorded but they were short-lived. Consequently, it was decided that no further field trials would be mounted in the east until a suitable formulation was available and had been thoroughly tested.

Meanwhile, in the west, plans went ahead for a trial in 1979 against the western spruce budworm, using the synthetic attractant formulated in small flakes of laminated plastic, a product of the Hercon Chemical Corporation. Preliminary measurements of release rates appeared promising, and the product performed in the field much as anticipated. The flakes were applied at two rates giving 20 g and 2 g of synthetic material per hectare. The 20 g dosage gave 87 percent reduction in trap catches, the 2 g dosage, 80 percent. However, at neither rate were subsequent egg densities significantly reduced. Either the treatment did not produce a sufficient degree of disruption, or the areas were invaded by mated females from outside the treated plots.

## Conclusions

The chemistry of the pheromones has been thoroughly investigated. "Early warning" trapping systems appear promising in the west and in the east, but require intensive efforts to correlate trap catches with subsequent damage or population density changes, and to establish thresholds for management action. Trials involving the atmospheric permeation with the pheromone have demonstrated that male orientation is disrupted and that this can affect numbers in the following generation. However, future trials require a thorough evaluation of the candidate formulations under field conditions. An urgent need is seen for a technique for measuring airborne concentrations of attractants. Further field trials are in the planning stage for the west in 1980 and are under consideration for the east.

*G.E. Daterman* — Pacific Northwest Forest and Range Experiment Station, USDA-FS, Corvallis, Oregon
*C.J. Sanders* — Great Lakes Forest Research Centre, CFS, Sault Ste. Marie, Ontario



**The Use of Radar in Detecting Spruce Budworm Moth Dispersal**

A research program in New Brunswick coordinating the use of radar, specially-instrumented aircraft, and observations from platforms extending above the forest canopy has established the massive scale and regularity of July evening takeoff flights by spruce budworm moths and of subsequent nocturnal dispersal at levels high above the ground.

An observation platform was first used in 1970, and a flight pattern of budworm moths could be seen from it that had not been visible before from the ground. Moths were seen taking off abruptly from the tree tops and climbing steeply above the canopy before moving off downwind, and still climbing, disappearing out of sight. On windy nights the steep exodus climb was brief, but on quieter evenings, the moths climbed almost vertically 15 meters or more above the canopy before encountering wind speeds greater than their flight speed. Here they turned, headed downwind and emigrated out of the stand.

Moth takeoffs begin in the evening around 1930 hours when light intensity is starting to decrease noticeably. The vast majority of moths take off when canopy temperatures are falling from 23 to 18°C. On warm evenings takeoffs peak around darkness at 2200 hours, and seen through a night-viewing telescope, all takeoffs cease before midnight. On cooler evenings, the moths take off earlier and on many nights at cool sites, such as the north central highlands of New Brunswick, no moths take off because canopy temperatures fall below the threshold, 15°C, early in the evening before light intensity has started to decrease. Fourteen hundred budworm moths in steep exodus climb have been captured from observation platforms, of which 79 percent were females. They carried, on the average, 45 percent of their eggs.

Radar was used in New Brunswick from 1973 to 1976 to monitor airborne populations of dispersing moths. A radar unit located in a forest clearing appears in the center photograph. The antenna, the circular dish mounted on the van, rotates at a rate of one revolution per three seconds and emits a narrow beam of energy with a wavelength of 3.2 cm. The antenna is steerable so that the beam can be raised or lowered similar to a searchlight scanning the airspace at night. The photograph on the left shows the radar screen on July 10th at 1700, two hours before any budworm had taken off that evening. The angle of elevation of the antenna was 18° above the horizontal. The white-out and the cluster of echoes in the center of the screen are referred to as ground clutter and arise from stray energy from the beam striking the tops of trees surrounding the radar site. The three rings appearing on the screen are range markers and delineate distances of 450, 900, and 1350 m along the beam. When an aircraft, bird, bat, or insect flies through the beam, energy is reflected back to the radar and an echo appears on the screen as a dot of light. The two echoes on the left of the screen are from single insects flying at altitudes, calculated trigonometrically, of about 200 and 550 m.

The peak time of budworm takeoff on July 10th was 2215 when the canopy temperature was 18.5°C. The photograph on the right shows the radar screen at 2202; the echoes are mostly from spruce budworm moths. A single-engine Cessna aircraft with an insect-collecting net fastened to the underwing was used nightly to sample the airspace above the radar site. At the time of the photograph, the aircraft was netting spruce budworm moths almost exclusively. Notice that there is a layer of concentrated echoes at the 900 m range ring, at a corresponding altitude of approximately 280 m. Few insects were flying higher. Prominent layers of this type appear on the radar on most nights. Echoes closer to the center of the screen are from moths recently taken off from the forest near the radar and still climbing to the preferred cruising altitude.

Notice also that in general there are more echoes appearing at long distances to the NE and SW compared to the SE and NW. The radar beam when striking an insect body sideways provides a larger echo then when the beam hits the insect head-on or tail-on. The distribution pattern of echoes indicates that the majority of the dispersing moths have their bodies aligned in the same direction. They have a common orientation and

are flying in the same direction. A pilot balloon released from the radar site at 2211 hours showed the wind at all altitudes up to 300 m was from the SE. Similarly a DC-3 aircraft with Doppler wind-finding equipment, which was used nightly to explore wind fields over New Brunswick, provided a detailed profile of wind and temperature over the radar site on July 10th. This showed the wind at the cruising altitude of the moths was from the SE and the air temperature 22.5°C, some 4 degrees warmer than the canopy. Had the moths levelled off that evening 100 m higher, they would have dispersed in a northerly direction, and if flying at 500 m, in a northeasterly direction.

Estimates of the total number of moths per hectare flying above the forest at any hour are derived from radar counts of the number of echoes in a standard area of the screen. These counts, which are repeated for a series of nine elevation angles of the antenna between 3 and 65 degrees, are integrated with respect to height. Airborne densities over New Brunswick of tens of thousands of moths per hectare were common on four or five nights at mid-moth season.

The durations of flights varied from a fraction of an hour to several hours, even to dawn. On one-third of the nights the moths travelled 20 km. On another one-third of the evenings the moths travelled about 60 km. The remaining flights continued for 3-6 hours, and the moths travelled 120 to 180 km.

The almost overwhelming importance of this adult dispersal process to budworm-forest dynamics and the development of control strategies has clearly been demonstrated via the budworm/forest simulation model. A great deal of useful information on this process has been obtained over the past few years, but some vitally important questions remain to be answered before moth movement can be predicted or even detected with a reasonable degree of success. Questions such as: what triggers moth takeoff?; do moths have any control over the kind of site on which they land?; what influence does the recently discovered sea breeze phenomena and other air movement patterns have on moth redistribution? — these are currently being addressed by the Maritimes Forest Research Centre, the Atmospheric Environment Service, and the University of New Brunswick.

*Dave Greenbank* — Maritimes Forest Research Centre, Fredericton, N.B.

**CFS Workshop on Remote Sensing**

A two day workshop on remote sensing was held in Hull, Quebec, at CFS-HQ, Place Vincent Massey. The meeting, chaired by Les Carlson, Phil Gimbarzevsky and Peter Kourtz, hosted 20 CFS researchers from across Canada. The goals of the workshop were to identify priority uses of remote sensing technology in forestry research and operations, and to develop recommendations for CFS program action. One-half day was devoted to a regional review of remote sensing activity. Also Dr. Murray Strome from the Canada Centre for Remote Sensing brought the group up to date with new remote sensing technology, notably the introduction of LANDSAT-D in 1981-1982.

The workshop recommendations included the establishment of a coordinator of remote sensing technology to ensure the best exploitation of that technology in CFS programs. Of particular interest to the CANUSA program is the recommendation that an entomologist with remote sensing background, a sampling statistician, and a remote sensing expert form a team to develop remote sensing techniques for damage appraisal work. The first priority problem they are to work on is spruce budworm damage.

Other recommendations dealt with technology transfer programs, communications between researchers, development of Ecological Land Classification maps, and remote sensing hardware purchases and evaluations.

**Upper Peninsula Information Meeting**

A spruce budworm information meeting was held in Escanaba, Michigan on December 13th, 1979. Approximately 75 persons representing small private landowners, corporations and public forest management agencies attended an all day session aimed at information exchange on the budworm problem. Technical recommendations on silvicultural options were provided by Bob Frank and John Benzie, USDA-FS. A view of the budworm and its current status was given by Nancy Breisch, Michigan Technological University; Bob Heyd, Michigan Department of Natural Resources; and Bob Ford, USDA-FS. Current and potential utilization options for damaged fir were presented by Steve Sinclair, University of Minnesota. Dan Schmitt, CANUSA-East, highlighted CANUSA research in progress. An overview of demonstration projects was given by Bob Ford, USDA-FS; Karen Olson, Greentree Consultants; and Marcia McKeague, Michigan State University. John Witter, University of Michigan, and Gary Simmons, Michigan State University, detailed research studies being conducted in the Upper Peninsula.

Attendees indicated a need for additional information on options available today to help address the problem. Private landowners voiced particular concern that large-scale spraying programs had not been contemplated for the Upper Peninsula.

The information meeting was hosted by Nancy Breisch and Bob Heyd and was coordinated by John Witter and Gary Simmons. Many agencies co-sponsored the meeting including: Michigan Technological University, University of Michigan, Michigan State University, Michigan DNR, USDA-FS, CANUSA, the Cooperative Extension Service, and the Michigan Cooperative Forest Pest Management Program. An information booklet summarizing the formal program was distributed to all attendees. Additional copies may be obtained by contacting John Witter or Gary Simmons, Entomology Dept., Michigan State University, E. Lansing, Michigan 48824.

**CANUSA Program Managers Meet**

The Olde Colony Inn, Alexandria, Virginia, was the site of the first joint CFS-USDA Forest Service Program Managers Meeting, February 4-7, 1980. The locale was significant, in as much as the Spruce Budworm Symposium held there in November 1974 sparked a major interest in a joint Canada-USA spruce budworms program that eventually culminated in the CANUSA agreement. The Meeting opened with an informal dinner followed by an address by Keith Shea, now Associate Deputy Chief for Research, USDA Forest Service, and one of the authors of the original agreement. Luncheon speakers on subsequent days included Dave Ketcham, Environmental Coordinator, USDA Forest Service, speaking on advantages and pitfalls of the U.S. "Big Bug Programs," and Jim Stewart, Director FIDM, with an insight on current trends in forest pest management.

The managers, representing all program components, wrestled during the course of the sessions with such issues as organization and structure, communication, integration and coordination, program priorities, projected accomplishments, special interest topics, program products, and transition plans following the termination of the agreement. For a number of the participants it was their first meeting, but the "get acquainted period" was amazingly short and they rapidly became embroiled in getting on with the job of coordinating the CANUSA program. The venue, near Washington, provided the group an opportunity to meet and discuss mutual interests with a number of the Washington office staff, many of whom play significant roles in the CANUSA program. These included Gerald Anderson, Director of FIDR and co-chairman of the JPU; Stan Barras, FIDR; John Neisess, FIDM; Bob Brandt, International Forestry; Bill Hamilton and George Castillo, Office of Information; Dick Knox and Hal Marx, Technology Transfer; and Norm Gould, Timber Management.

A number of recommendations emerged that will improve structure, coordination and communication, and expedite joint programs. The group plans to meet again after the fall Working Group Meetings at which time recommendations from the scientific and resource manager communities could be incorporated into the program.

**Budworm Biosystematics Activities Discussed at Berkeley**

Biosystematics of western budworms was the central topic of an informal meeting held January 9, 1980, on the Berkeley campus of the University of California. Attendees included Jerry Powell, Jan Volney, and Bill Waters, University of California at Berkeley; their students Pat Akers, John DeBenedictis, and Sandy Lieboldt; Molly Stock, University of Idaho; P.T. Dang, Biosystematics Research Institute, Ottawa; and Bob Stevens, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

The objective of the session was to share information and help in coordination of CANUSA-sponsored studies in which *Choristoneura* biosystematics is a major goal or an important facilitating element. Jerry Powell, Bob Stevens, and Gary Daterman, Pacific Northwest Forest and Range Experiment Station, USDA-FS, Corvallis, Oregon, are coinvestigators on a biosystematic study of the western members of conifer-feeding *Choristoneura*, and P.T. Dang has recently been assigned similar responsibilities in Canada. Jan Volney and Bill Waters are studying the dynamics of several budworm populations in southern Oregon and northern California that present unusual taxonomic questions, and Molly Stock is working in the area of isozyme characteristics of budworm populations.

The meeting, chaired by Jerry Powell, afforded a good opportunity to further plans for cooperative efforts in the forthcoming field season.

**Pest Management Workshop**

"What is going on in Integrated Pest Management" is the theme of a workshop to be held by the USDA Forest Service, Forest Insect and Disease Management Staff. Place: Denver. Dates: April 22-24, 1980. Intended audience: pest management specialists in the Forest Service Regions and Areas, and in Cooperating State agencies. For more information, contact Bill Ciesla, USDA Forest Service, Methods Application Group, 2810 Chiles Road, Davis, California 95616.

**1980 Annual Meeting of CIF**

The 1980 Annual Meeting of the Canadian Institute of Forestry will be held in Ottawa on October 5-9, 1980. The theme is Forestry in Canada: The Role of Governments. Our recent awakening to the real state of forest management in Canada and the need for sharply increased inputs if our industry is to be sustained, has stimulated discussion on the roles and responsibilities of all the participants. An intent look at the role of governments is timely; Canada's capital is a logical place. Prominent foresters, government officials, political scientists and politicians are being invited to speak.

**Biosystematic Study in Canada**

A biosystematic study of the spruce budworms, *Choristoneura fumiferana* (Clemens) (eastern spruce budworm) and *Choristoneura occidentalis* Freeman (western spruce budworm) complexes in Canada is being undertaken at the Biosystematics Research Institute, Ottawa, as part of the CANUSA spruce budworms program. The overall objective of the study is to search for reliable morphological and biological characters for distinguishing siblings of these complexes. A basic step is to gather long series of specimens of a pure population from various localities and host plants across Canada and the United States (especially Alaska). This study will require a careful rearing program in the laboratory where all stages of the second generation will be

collected and preserved for morphological study. The artificial diet described by Robertson will be used. The behavioral and genetic aspects of members of the complexes are also being studied in this Institute.

P.T. Dang of the Canadian Forestry Service, Department of Environment, Ottawa, is the principal investigator. He is extremely interested in obtaining live material of either eggs, larvae, or pupae collected from all parts of Canada and Alaska. You can help by sending him live specimens from your working area (be sure to record host plant) so that he will be able to obtain material from as many different localities as possible for rearing. Importation permits available on request. Your assistance would be greatly appreciated. Mailing address: Dr. P.T. Dang, Canadian Forestry Service, c/o Biosystematics Research Institute, K.W. Neatby Building, Agriculture Canada, Ottawa, Ontario, K1A 0C6.

**Spruce Budworms Infestation in the United States in 1979**

Surveys for visible defoliation by the spruce budworm and western spruce budworm in the summer months of 1979 provided the information summarized below:

| Area | Acres Infested |
|---|---|
| Northern Region | 2,300,000 |
| Rocky Mountain Region | 930,000 |
| Southwestern Region | 130,600 |
| Intermountain Region | 1,414,000 |
| Pacific Northwest Region | 407,000 |
| Subtotal — West | 5,181,600 |
| Northeast | 6,025,000 |
| Lake States | 622,000 |
| Subtotal — East | 6,647,000 |
| Total — United States | 11,828,600 |

Suppression activities were reported in CANUSA Newsletter No. 6, September 1979.

**Taking Advantage of Good Budworm Populations**

Bill Waters and Jan Volney will be extending their population dynamics work to New Mexico. Bill's project to look at low level populations and the "release" phase of "epidemics" will continue at a lower level in Northern California and Southern Oregon.

**Field Tests of B.t. in the West**

Plans are rapidly moving ahead to conduct a field test of B.t. on the Kaibab Plateau near the north rim of the Grand Canyon. Three formulations of B.t. are currently proposed for the test with the possibility of adding a fourth, if needed. Western and Eastern components in the U.S. and Canada are coordinating the selection of formulations and, to some extent, test design to insure comparability of results.

Although the new B.t. + oil (Dipel L4) formulation was recently registered for "budworms," making it available for use in the west, the Program feels a test is necessary to establish the efficacy of this and other formulations to make these materials acceptable to land managers.

By coordinating these tests with one being scheduled in British Columbia, the Program will have data from roughly the northern and southern extremes of the budworm range. This should help in estimating the probable efficacy of these materials in other areas.

**Region 3 Following Budworm for Years**

The Southwestern Region (Region 3) FI&DM staff have been following the effects of a budworm suppression project for the past three years. The work, being done in cooperation with Sante Fe National Forest, will be useful to investigators interested in assessing budworm damage and the effects of selected control efforts on that damage.

In another study, two years of data have been collected on damage to Douglas-fir, true fir, and spruce resulting from a budworm outbreak that began in 1975. This study, funded by FI&DM and carried out in cooperation with the Carson National Forest, should provide interested investigators with information on budworm population density and associated impacts.

Contact Cathy Stein, the CANUSA representative in Region 3, for details on either of these studies. She can be reached at:

USDA-FS — Forest Insect & Disease Management
Federal Building
517 Gold Avenue SW
Albuquerque, New Mexico 87102
(505) 266-2440
FTS 474-2440

**Antifeedants for the Spruce Budworm**

For many insects, the selection or rejection of a particular host plant for feeding is influenced, at least in part, by the presence in the foliage of phago-stimulants or -deterrents. Included among the latter are antifeedants, defined as substances which, when tasted, can result in cessation of feeding, either temporarily or permanently, depending on potency.

One of the most powerful insect antifeedants known is azadirachtin, isolated from leaves and berries of *Azadirachta indica*, the Indian neem tree. This compound exhibits strong antifeedant activity against a number of insect species, but most notably *Schistocerca gregaria*, the desert locust. These insects will starve to death rather than feed on leaves which have been surface-treated with only a few nanograms of azadirachtin per square centimeter! The compound does not appear to be generally toxic: neem sticks are chewed in parts of Africa and India to clean the teeth, and are also used as a remedy against malaria. Furthermore, berries of the tree constitute the favorite diet of several bird species.

The principle presents an intriguing possibility for spruce budworm management. If a cheap, easily produced, nontoxic material could be developed to prevent spruce budworm larvae from feeding, it would greatly enhance the arsenal of tactics available to the resource manager. This possibility was recognized independently by scientists at the University of Maine, Orono, and the Maritimes Forest Research Centre of the Canadian Forestry Service. A collaborative research program has recently developed to enhance this mutual interest.

At Orono, entomologist Dave Leonard and chemist Mike Bentley have developed a convenient and reproducible assay for observing antifeedant effects on sixth instar budworm larvae. Given an adequate supply of larvae, the method is suitable for an extensive screening program of nonhost plant extracts and other materials. The Maine scientists have already tested more than one hundred extracts with some encouraging results. Additional extracts are being prepared by George Strunz, a chemist at the Maritimes Forest Research Centre in Fredericton. Supplies of larvae for the bioassay are obtained from the Forest Pest Management Institute, Sault Ste. Marie, Ontario.

As in other research encompassing more than one discipline, close collaboration between chemists and biologists is a key feature of this study. Extracts which show promising antifeedant activity in the initial screens are fractionated into their many constituents, using a variety of chemical separation techniques. The fractions are monitored by bioassay, and material possessing the desired activity is purified. The molecular structure of the pure antifeedant may then be elucidated through chemical and physical studies.

It is difficult to assess the prospects of isolating a material that satisfies all the necessary criteria: ease of production either by extraction from natural sources or by syntheses; low nontarget toxicity; and economical production and application costs. The research team involved in this program is certainly confident of eventual success. Let's hope we soon have a large population of hungry budworm as a result!

**New CANUSA Personnel**

The Washington Office welcomes Angela Dotson, who replaces Linda Hertzog ("Linda east") as Mel McKnight's right hand, and Phyllis Ott, who has replaced Linda Burback (Linda west") in a similar capacity for Max McFadden. Bob Taylor, former pesticide evaluation officer with Agriculture Canada, has joined the Ottawa staff as Chuck Buckner's assistant.

**Publications**

You folks working in environmental safety of insecticides should take special interest in "Response of Breeding Birds to Aerial Sprays of Trichlorfon (Dylox) and Carbaryl (Sevin-4-Oil) in Montana Forests." Ask for Special Scientific Report — Wildlife No. 224 from U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, Maryland 20811.

A new publication from CANUSA-West provides "how-to-do-it" information on initiating and maintaining colonies of spruce budworms in the laboratory. Although the method is presented for the western spruce budworm, it is said to be equally useful for the spruce budworm and other *Choristoneura*. Ask for "Rearing the Western Spruce Budworm," by Jacqueline L. Robertson from the Pacific Southwest Forest and Range Experiment Station, Box 245, Berkeley, California 94701. Please take special note that this is an excellent example of the use of the CANUSA Style and Design Manual (See Newsletter No. 2) for interior pages as well as cover. Take the time to dust off the Manual and review the recommended formats for various reports and publications.

Pacific Northwest Forest and Range Experiment Station (809 NE Sixth Avenue, Portland, Oregon 97232) has released "Evaluation of Sticking Agents Mixed with *Bacillus thuringiensis* for Control of Douglas-fir Tussock Moth," by John Neisess. Ask for Research Paper PNW-254.

"Western Spruce Budworm Population Densities and Defoliation One Year After Insecticide Treatment of Small Blocks" is the title of Report 80-1, available from Methods Application Group, Forest Insect and Disease Management, USDA Forest Service, 2810 Chiles Road, Davis, California 95616.

"Aerial Applications of Nuclear Polyhedrosis Virus and *Bacillus thuringiensis* Against Western Spruce Budworm" by R.S. Hodgkinson, M. Finnis, R.F. Shepherd and J.C. Cunningham. Ask for BCMF/CFS Joint Report No. 10, October 1979, from the Pacific Forest Research Centre, 506 West Burnside Road, Victoria, B.C. V8Z 1M5.

"The Spruce Budworm Situation in Ontario" by G.M. Howse and A.A. Harnden, Report O-X-300 is available from the Great Lakes Forest Research Centre, P.O. Box 490, Sault Ste. Marie, Ontario P6A 5M7.

To insure that the NEWSLETTER does its part, we need your help. Additions and corrections to NEWSLETTER mailing lists should be sent to the Program Leaders. We will welcome your comments and questions on the content of CANUSA NEWSLETTERS, and especially your suggestions for future issues.

C.H. Buckner
Program Leader-Canada
Canada/U.S. Spruce
Budworms Program,
Canadian Forestry
Service,
19th Floor,
Place Vincent Massey,
351 St. Joseph Blvd.
HULL, Quebec
K1A 0E7

M.E. McKnight
Program Leader-
United States
Canada/U.S. Spruce
Budworms Program,
USDA-Forest Service,
P.O. Box 2417,
605 RP-E
Washington, D.C. 20013